circuit according to a preferred embodiment of the present invention.

FIG. 2 is a schematic circuit diagram of the DC bias equivalent circuit according to a preferred embodiment of the present invention.

[Detail Description of the Invention]

[Objects of the Invention]

[Field of the Invention and Background of the Invention]

The present invention relates to a subscriber matching circuit for an electronic exchange. In particular, the present invention relates to a subscriber matching circuit for an electronic exchange which matches transmitted/received data so as to permit call communications between the exchange and subscribers.

Generally, in an electronic exchanger, a subscriber matching circuit for matching with subscribers requires the functions of line current supply, supervision of a subscriber's state, call signal supply (ring signal supply) and detection, 2-line/4-line conversion, etc. The line current supply function serves to supply current for operating a subscriber's telephone and to supervise the on-hook/off-hook state of the telephone by detecting the variation of the supplied current. The line current supply function, which is performed with a function of limiting a maximum line current, serves to prevent unnecessary power consumption due to an oversupply of the line current to a short-distance subscriber. The 2-line/4-line conversion function serves to convert a 4-line signal transmitted from the telephone exchange or through transmission lines into a 2-line signal, while converting the 2-line signal transmitted from the subscriber's telephone into the 4-line signal.

Such an analog type subscriber matching circuit may employ a conventional transformer. However, it cannot be adapted to the present-day trend of the high-density integration and miniaturization due to its large size and magnetic saturation caused by the line current. In order to adapt the trend of the high-density integration and miniaturization, the subscriber matching circuit has been integrated into an SLIC integrated circuit (IC). A subscriber matching circuit using the SLIC IC is disclosed in Korean Patent Application No. 1994-40809 filed by the applicant of the present invention. According to the subscriber matching circuit disclosed in Korean Patent Application No. 1994-40809, however, all circuit elements are integrated onto one chip, and thus it is relatively vulnerable to external impacts such as lightning strikes in comparison to the circuit employing the transformer. As a result, it requires a protection device as well as many peripheral parts thereof for performing the subscriber matching function, thereby increasing the possibility of experiencing difficulties in operation.

[Technical objects for supporting the present invention]

It is an object of the present invention to solve the problems involved in the related art, and to provide a hybrid subscriber matching circuit for an electronic telephone exchanger which can simplify the peripheral parts thereof and strongly resist an external impact or shock.

[Structure and Operation of the invention]

The embodiment of the present invention is described in detail hereinafter

with the accompanying drawings.

FIG. 1 shows an embodiment of the hybrid subscriber matching circuit according to the principle of the present invention.

The hybrid subscriber matching circuit for a full electronic exchanger according to the principle of the present invention includes transistors Q1 and Q2 supplying a line current to a subscriber through a tip terminal and a ring terminal, transistors Q3 and Q4 having a Darlington structure connected to the transistors Q1 and Q2 respectively and limiting a maximum current, current supervising resistors R1 and R2 connected to emitters of the transistors Q1 and Q2 respectively and performing a current feedback operation to limit the maximum current and detecting a voltage form of a line current flowing through telephone lines, a resistors R3 connected between a collector of the transistor Q1 and a collector of the transistor Q3 and preventing the transistors Q1 from being saturated, a resistor R4 connected between a collector of the transistor Q2 and a collector of the transistor Q4 and preventing the transistors Q2 from being saturated, three bias resistors R5, R6 and R7 determining a threshold value of the maximum current and allowing the transistors Q1 and Q2 to be in an active state, diodes D1 and D2 preventing the transistors from being overheated due to a variation of the threshold value of the maximum current and the heat generated by the line current (I_L), bypass capacitors C1, C2, C3 and C4 preventing a bad influence on call communications due to the generation or induction of noise introduced in the DC line current supply, capacitors C5 and C6 superimposing a received audio signal (i.e., an AC signal) on the DC line current, composite impedances ZL1 and ZL2 matching line characteristic

impedance, amplifiers AMP1 and AMP2 receiving and amplifying the audio signal, protection elements CR1 and CR2 protecting the amplifiers AMP1 and AMP2 from being an over current state through lines, a resistor R11 converting the line current flowing through the resistor R1 into an input current for detecting an off-hook state, an operational amplifier AMP3 inversion-amplifying a signal inputted through the resistor R11, a resistor R13 determining an amplification factor of the signal inputted through the resistor R11, a transistor Q6 converting a level of the signal inversion-amplified by the operational amplifier AMP3, a resistor R10 detecting a ring trip voltage if a telephone handset is hooked off during supply of a call signal, a resistor R12 converting the voltage detected by the resistor R10 into a ring trip current, a capacitor C7 allowing the operational amplifier AMP3 to serve as a low-pass filter so that an AC amplification factor is greatly lowered to remove AC ripple components included in the ring trip current, and a field effect transistor FET1 allowing the operational amplifier AMP3 to serve as a low-pass filter in a ring current supply state.

FIG. 2 shows the DC bias equivalent circuit according to the principle of the present invention.

The operation of the embodiment of the present invention is now explained in detail with reference to FIGS. 1 and 2.

The transistors Q1 and Q2 are to supply the current, and the transistors Q3 and Q4 are to limit the maximum current. The equivalent circuit of FIG. 2 performs the line current supplying function. Since the circuit for supplying the line current

increase of the current Ib1 through the resistor R3. The bias stability is improved by the voltage feedback which decreases the collector voltage V_{CE1} of the transistor Q1. Another important role of the resistor R3 is to prevent the saturation of the transistor Q1. Specifically, if the resistor R_L of the speech line increases, the line current (I_L) and the collector voltage V_{CE1} of the transistor Q1 decrease. The decrease of the line current (I_L) causes the decrease of the amount of the current feedback through the resistor R1. The continuous increase of the resistor R_L of the speech line causes the continuous decrease of the line current (I_L) and results in that the collector voltage V_{CE1} of the transistor Q1 extremely decreases to reach the saturation region of the transistor Q1. At this time, the base current Ib1 of the transistor Q1 which is supplied through the resistor R3 decreases due to the decrease of the collector voltage V_C of the transistor Q1, and thus the saturation of the transistor Q1 is prevented. Actually, this prevents the distortion of the AC characteristic in a long loop in which the line resistor RL increases.

Also, the maximum current limitation is effected by the current feedback through the resistor R1. The increase of the line current I_L causes the increase of the terminal voltage V_{R1}, and the current limitation is performed when the line current (I_L) reaches a value corresponding to the state that the voltage of $V_R1+V_{BE}1+V_{BE}2$ becomes equal to the voltage of V1. However, if the current limitation is actually generated due to the current increase, V_{CE} of the transistor Q1 increases, and this causes the power consumption as much as I_L1*V_{CE} to be generated in the transistor Q1, resulting in heat generation in the transistor Q1. Since V_{BE} is in negative

proportion to the temperature (that is, -2.4mV/°C), V_{BE} decreases as the temperature increases, and this causes the current limitation value increases. An undesirable repetition of such operations results in an error in the limited current. As a result, the maximum current, much higher than the limited current actually required, flows. In order to prevent this overheating phenomenon, the diode D1 which has a forward voltage-temperature characteristic is connected between the base of the transistor Q2 and the ground. In this case, since the forward voltage of the diode decreases to the same level as V_{BE} of the transistors Q1 and Q2 due to the heat generated in the transistor Q1, the variation of the limited current to the temperature is offset, and thus the limited current can be more stably determined. Though the transistors Q1 and Q2 are connected in a Darlington structure, the base current Ib1 of the transistor Q1 is actually limited by the resistor R3. The purpose of this construction is not to improve the voltage gain by supplying an input signal to the base of the transistor Q2, but to improve the gain of the current feedback performed by the resistor R1. In other words, when the resistor R_L of the line varies within the range of the limited current, the limited current is kept constant with respect to the variation of R_L of the line by the transistors Q1 and Q2.

Meanwhile, the line current supervising function serves to convert the line current into a logic signal by driving the transistor Q6 with an inversion-amplified output of the voltage variation of the resistor R1. The line current supervising circuit of FIG. 1 also performs the ring trip function simultaneously. Specifically, if the line current (I_L) increases, the voltage drop is generated by the resistor R1, and this voltage drop is inversion-amplified with the gain determined by the resistors R11

and R13 to drive the transistor Q6. If the transistor Q6 is driven, a logic "0" (low) signal is outputted from the collector of the transistor Q6 to a detection terminal DET. At this time, the line current (I_L) corresponding to the condition that the detection terminal DET is in the logic "0" state is determined by the resistors R11 and R12. The line current supervising circuit also supervises whether the handset is hooked off if the ring current is supplied during the supervision of the line current (I_L). Specifically, a ring relay K1 is switched to the resistor R10, and the ring current supplied from the ring terminal is applied to the tip terminal via the line resistor R_L and the terminal telephone. In the off-hook state, the line resistor R_L including the DC resistance of the terminal telephone decreases abruptly, and this causes the voltage drop formed between the terminals of the resistor R10 to increase. This dropped voltage is applied to the inverting terminal of the operational amplifier AMP3 through the resistor R12 to be inversion-amplified. Accordingly, the output signal of the operational amplifier AMP3 becomes high, and is applied to the base of the transistor Q6 to turn on the transistor Q6, so that a low level signal is outputted to the detection terminal DET to indicate the off-hook state of the telephone. When the voltage drop of the resistor R10 increases, the signal inputted to the inverting terminal of the operational amplifier AMP3 for inversion-amplifying the terminal voltage of the resistor R10 becomes the DC signal superimposed with the AC ring signal, and thus it is required to greatly reduce the gain of the inversion amplifier AMP with respect to the AC signal in order to detect the DC signal only. The reduction of the AC gain in the operational amplifier AMP3 invites the reduction of the AC gain by the capacitor C7 connected in parallel to the

resistor R13, and thus the DC signal with its ripple component greatly suppressed is outputted from the operational amplifier AMP3, enabling the ring trip operation to be performed accurately. The field effect transistor FET1 is turned on only when the ring relay K1 operates, and thus has no effect on the line current supervising function in a normal state. At this time, since the capacitance of the capacitor C7 cannot be selected as an infinite value, the resistors R11, R12 and R13 should have a large resistance value in the range of several hundred kilo-ohms (KΩ) in order for the capacitor C7 having a small capacitance value to act as a low-pass filter.

[effects of the invention]

As described above, the subscriber matching circuit according to the present invention is designed to use general parts while it performs the same function as the conventional analog subscriber matching circuit using a transformer or SLIC, and thus the manufacturing cost thereof can be greatly reduced. Further, the subscriber matching circuit according to the present invention has an on-hook transmission function, and thus can be applied to additional services such as remote charging, transmission of a calling subscriber's number, etc.